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BREEDING METHODS IN LIVESTOCK IMPROVEMENT *

PROBABLY at no time during the past hundred years has there been so much current of changed attitudes and values sweeping through the minds of stockbreeders. While the general public may have noted the effects of the war-time food policies on milk production and on the sheep, pig and poultry populations, it is fair to suggest that only those who face the practical aspects of the British livestock industry recognize the multiplicity of problems that the war situation, added to the general trends, has left. The recent years have thrust many changes upon this branch of British agriculture—not the least of which may be those of thought regarding the aims, methods and responsibilities of the different sections of the industry. It may be significant, in one sense, that, throughout the whole of the recent meetings of the British Society of Animal Production, the well-known and still hardy phrase 'the stud farm of the world' was not once used. There was no lack of opportunity, since breeding methods, techniques and aims were the main items under discussion.

The situation in poultry breeding adumbrates also some of the major problems of improvement in the larger farm animals. As Mr. Michael Pease defined it, the empirical methods of the past have more or less rapidly raised production to a level or ceiling beyond which progress is slow or impossible—the practical problem now is not grinding up but seeking enhanced production within 'improved' stocks. His work at Cambridge and Reaseheath represents one approach to the problem in poultry, that of Dr. A. W. Greenwood at Edinburgh another, and complementary, attack. The former utilizes inbreeding to develop lines, which may or may not be of the same productivity as the control stocks, but which may be combined to give more productive outbred lines within the pure breed. This procedure, deliberately pursued, is new to practical stockbreeding in Great Britain; and the investigations now in hand, involving 'top crossing' inbred lines, are designed to discover the part that cross-breeding can play in improving performance and whether it can produce as good stock as does out-breeding. Within the White Leghorn breed and under the specific conditions of these experiments, there has been no

*Article by J. E. Nichols reproduced from *Nature*, Vol. 157, p. 523, 1946.

significant increase of egg production so far, but the results are sufficiently encouraging to warrant continuance of the work.

The Edinburgh investigations also use the inbreeding technique, but in different degrees, and to the different end of studying the physiological components of egg production. A series of selected inbred lines of Brown Leghorns has been established under as uniform as possible conditions of feeding and management, each line being distinguished by one particular attribute, such as intensity of laying, persistency, small egg size, large eggs, body size, etc. Concentration on a single productive characteristic in one line has enabled not only the genetic basis of that character to be studied but also the significance of other important conditions, such as mortality, livability, and resistance or susceptibility to tumours, to be recognized and analysed in relation to the practical requirements of high production, vigour and stamina.

The larger farm animals cannot usually be kept in numbers under uniform conditions, so that differential responses to environment are important in practice. 'Suitability to environment' has been given lip-service as a breeding aim, yet the recession of the breeding centres, which follows, perhaps inevitably, the phase of widening influence, and distribution of improved types, emphasizes the significance of adaptability of type to environment. Moreover, the ways in which a breed population is built up, in relatively small units, with possibly different breeding systems and standards in these units, point to the necessity that breeding policies should relate to the breed as a whole. The ultimate problem is that of the frequency of desirable, or undesirable, genes within the breed; it is one of population genetics.

However, as Dr. J. E. Nichols was careful to point out in introducing the topic, economic, or performance, characters are greatly influenced by feeding and management; their hereditability is relatively low. Therefore the general question is one of discriminating between how much progress is attributable to genetic improvement, and how much is due to environment. The first, and probably the easiest, steps upwards from low average performance-levels can no doubt often be made by improved husbandry but the real genetic gains can only be achieved by appropriate selection and breeding methods. The discussion revealed doubts as to whether in the British dairy cattle breeding industry, for example, the necessary performance data have yet been acquired, or those available used enough, to enable modern selection procedures to be widely applied. Future progress will depend on suitable arrangements for the collection, analysis and interpretation of adequate data to provide standards of selective registration upon which the breeders can base their breeding policies.

A particular tool which may be used is artificial insemination, and a series of papers gave opportunity for a searching review of its practical application and problems.

Following an account of developments in Denmark, Canada and the United States, Mr. Twinch stated the essential requirements for comparing progress with artificial insemination—uniformity and simplicity in the systems of recording the relevant data, and agreement on methods of assessing the final results. Mr. D. L. Stewart described the organisation and administration of a centre, based upon experience at Reading, and directed attention to the need for all heifer offspring to be marked and afterwards recorded if the bull benefits of the technique were to be estimated. Mr. L. S. Rowson proved that proper care and management of bulls at centres involved more than control of nutrition and husbandry; inferior performance in service and failure of sex drive are largely attributable to mishandling of the psychological processes involved in the sexual act. The scope for observations on behaviour in this respect is immense; and such studies at the Cambridge centre show that the field for research is widened far beyond that of the physiology and biochemistry of reproduction. On the latter, Dr. Arthur Walton contributed an excellent historical summary together with a critical account of recent investigations, including those of the various fractions of egg-yolk medium in relation to their effects in sperm dilution and storage.

Dr. Walton's lessons that organisation must not be allowed to outrun knowledge, and that provision for fundamental research is essential, was fully supported by considerations raised by speakers concerned with the actual technique in its practical application. Thus, even with the necessary density of cow population within reasonable distance, the successful operation of an insemination centre depends upon a satisfactory recognition of the administrative, economic, and technical problems, in themselves and in their inter-relations. For example, if artificial insemination is to be used as a means for milch cattle improvement, a centre must clearly be able to supply semen from proved superior bulls. How can these sires be chosen with sufficient certainty? Are such bulls available in sufficient numbers and at a reasonable cost? The cost of inseminations must be made competitive with that of natural services; the results in terms of service efficiency, or conception-rates, must be comparable with natural matings, and those in terms of the performance of progeny must be demonstrably advantageous, so that farmers are encouraged to use the centres. Further, the centres must have definite long-term breeding policies.

NOTICE TO SUBSCRIBERS

The publication of the August, September and October issues of this Journal is unavoidably delayed through very heavy pressure of work at the Government Press, Trinidad.

PEASANT AGRICULTURE

An Economic Survey on the La Pastora Land Settlement, Trinidad, May 1944-45

BY

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PART I

The District

The settlement is situated at the head of the Santa Cruz valley in the Northern Range of the island. The bed of the valley is comparatively flat and rises to only about 300 feet above sea level over a distance of about 5 miles from the village of San Juan on the Eastern Main Road. The head of the Santa Cruz valley is however blocked by precipitous hills rising as much as 1,000 feet in half a mile. The settlement is situated on the flat plain and is surrounded on three sides by these cliff-like hills. The situation is extremely pleasant; the steep hill forest is always attactive and the settlement is near enough to the north coast (about one mile as the crow flies) for the cool sea winds to temper the air without causing discomfort from their constant bluster.

The soil* is generally fertile although there are small areas where fertility is not high. The good soils occur in the broad valley bottoms; they are acid loam and sandy loam with a water table at about 2 feet from the surface in the wet season and below 6 feet in the dry season. Actual soil profiles do not show much development of horizons; a yellowish-brown top soil merges gradually to a bright ochre yellow subsoil which in the region of water movement is slightly mottled, reddish orange. The whole profile is micaceous with a greasy feel. While they are classed as free draining they have sufficient clay in the subsoil to permit passage of water in shallow irrigation canals used for high class vegetable growing.

The poor soils occur in the narrow valleys and lower slopes at the head waters of small streams. They are very immature soils consisting of a few inches of acid yellowish brown loam overlying an orange-red, brashy loam full of mica, talc and graphite schist fragments. They are certain to be very poor in all plant nutrients and tend to dry out in the dry season.

The actual streams are bordered, several yards on either side, by recent river wash which when exposed to annual crops rapidly deteriorates but will support fair stands of tree crops. In appearance the profile here is a uniform yellowish-brown to olive-brown sandy loam full of shining mica and schist fragments, the latter becoming larger with increasing depth.

The settlement comprised an abandoned cacao estate and a few small properties at the time the government acquired it (1940 and 1941); the bush was generally very heavy and shade trees had reached vast dimensions; the responsibility of clearing the land fell to the settlers. Although much of the land had not been cultivated for some years, its fertility did not suffer under such dense vegetation.

About 100 settlers were selected by the Warden and Land Settlement Supervisor, and were offered a house and 2½ acres of bottom land each on a monthly cash tenancy from 1941 onwards. No specific qualifications were required for the selection of a settler; each was selected on individual merit, and preference was given to those who had previous agricultural experience. In no case, however, were settlers chosen because they were already successful farmers and would provide an example to others on the settlement; 44 of these settlers provided satisfactory information to the survey. They could not, however, be considered as representing the whole settlement, but rather the more enlightened enthusiastic individuals.

The Supervisor resident on the settlement was appointed in 1941. His duties were mainly instructional and included the management of a demonstration holding, the instruction of individual settlers and contact with Government Officials concerned with this and other settlements. Settlers could be evicted from their holdings by the Land Settlement Committee (and subsequently the Department of Agriculture which took over control of the settlement), for such misdemeanours as arrears of rent and "unsatisfactory" cultivation. These powers appeared in some cases to be very leniently administered; during the two months of field work, some twelve houses appeared never to be occupied.

Goods roads have been built through the settlement with piped water running along them. The roads connect with the Saddle road which leads to Port-of-Spain and San Juan both about 5 miles distant. The Saddle Road to Port-of-Spain is in places too steep for mule or donkey carts and produce for that market has to be taken by truck.

During the survey year most of the produce was sold to "marchands" (traffickers) who visited the settlement usually once a week. Previously, before motor tyres became scarce, three or four settlers owned some kind of motor transport with which they carried much of their own and neighbours' produce to market. The service rendered by the "marchands" was by no means satisfactory from the settlers' point of view, particularly in certain cases as explained below. Good service could, however, hardly be expected

* The description of the soil has been furnished by Dr. E. H. Chenery of the Department of Agriculture.

in view of the increases in food production within the last three years in areas larger than La Pastora and nearer Port-of-Spain.

No Co-operative Society has been formed on the settlement and this seems a great deficiency in the work of the original organisers. It would seem justifiable, from subsequent sections of this report, to make it compulsory for a peasant to be a member of a settlement Co-operative Society in order to qualify for a holding. Efforts in the past 18 months to form a Co-operative Society on a voluntary basis have met with no success.

A shop was built on the settlement but was not opened until the end of the survey year. The lack of shopping facilities has been a real hardship to settlers, because of the very irregular supply of imported foodstuffs during the war. If supplies were not available in Santa Cruz or Cantaro (combined population perhaps 300 persons), settlers had to make a full half day's excursion to Port-of-Spain or San Juan in search of their requirements. A settlement shop, because of close contact between purchaser and seller, would have eased this situation ; a shop also has the advantage of being a natural meeting place and news office which maintains the cohesion of the settlement.

The house provided on the holding is an undoubted amenity of the settlement. Many settlers spoke highly of the house and six of them gave it as their main reason for taking a holding. The design consisted of two bedrooms separated by a sitting room with a kitchen attached at the back. One point should, however, be noted by designers of small rural houses : where wood is available kitchens should be built under a separate roof : the settlers had great difficulty in obtaining charcoal because so little was made and used in the district ; wood fires were however impracticable for cooking because the smoke filled the settlement houses.

The People

The tenants at La Pastora were racially very mixed and represented all the important peasant farming races of the island : 18 East Indian farmers were interviewed ; 15 West Indians (pure and mixed negro blood) ; 10 Spanish Indians (descendants of intermarriage of white with the aboriginal Indians of the island) ; and one farmer of Chinese descent. This latter farmer has been included among the West Indian group to facilitate comparisons.

The unexpected feature of this racial analysis was the large number of East Indians farming in a typically hill district of the island. This feature was perhaps partly fortuitous and due to the fact that the East Indians were more dependent on their holdings for their livelihood and were therefore more often at home and easier to contact than the other races. It can be seen in Table 1 that East Indians had a larger agricultural income* which made up a larger percentage of their total income and had more time available for work on the holding than the other races. The settlement does, however, show that East Indians who originally settled in the plains of the sugar belt have spread to hill farming as well.

Table 1

Some Racial Characteristics

	East Indian	West Indian	Spanish Indian	All
No. of Farmers ..	18	16	10	44
Agricultural Income per Holding ..	$790	$640	$590	$691
Agricultural as % of Total Income ...	67	60	56	63
Man-days available per Holding	290	204	207	240

It was noticeable during the course of the survey that there was a strong community spirit among most of the settlers in spite of the very mixed population. The more progressive and firmly established farmers took an interest in the farming of their poorer neighbours (and *vice versa*). The example and enthusiasm of the well established farmers did no doubt broaden the outlook of the others to the possibilities of more difficult and profitable crops.

Although none of the non-agricultural races, (pure Chinese, Portuguese, Syrian, etc.) was represented in the sample, 26 out of the 44 farmers were not engaged in agriculture prior to taking up land at La Pastora. Nearly half of the agriculturists were Spanish Indians, so that the proportion of East and West Indians who were previously agriculturists was surprisingly low

Table 2

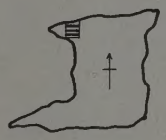
Comparison of Agriculturists and Non-Agriculturists

	Farmers previously engaged in :		All Farmers
	Agriculture	Other Occupations	
Number of Farmers ..	18	26	44
Ag. Income per Holding	$614	$744	$691
Ag. Expenditure per Holding	$215	$277	$253
% of Man-days available for Holding ..	46	37	41
Total Income per Total Man-day†	$1.42	$2.20	$1.87
Net Agricultural Income per man-day available	$2.00	$2.26	$2.13
Initial Capital	$184	$405	$316

† Includes time of all potential workers whether cash earnings were received or not.

*Definitions are those used in " Peasant Farming in the Bejucal area of Trinidad." *Tropical Agriculture*, **22**, 83-88, 1945.

TOPOGRAPHICAL MAP OF LA PASTORA LAND SETTLEMENT



SCALE

0 1 2

MILES

HEIGHTS IN FEET

0 – 500

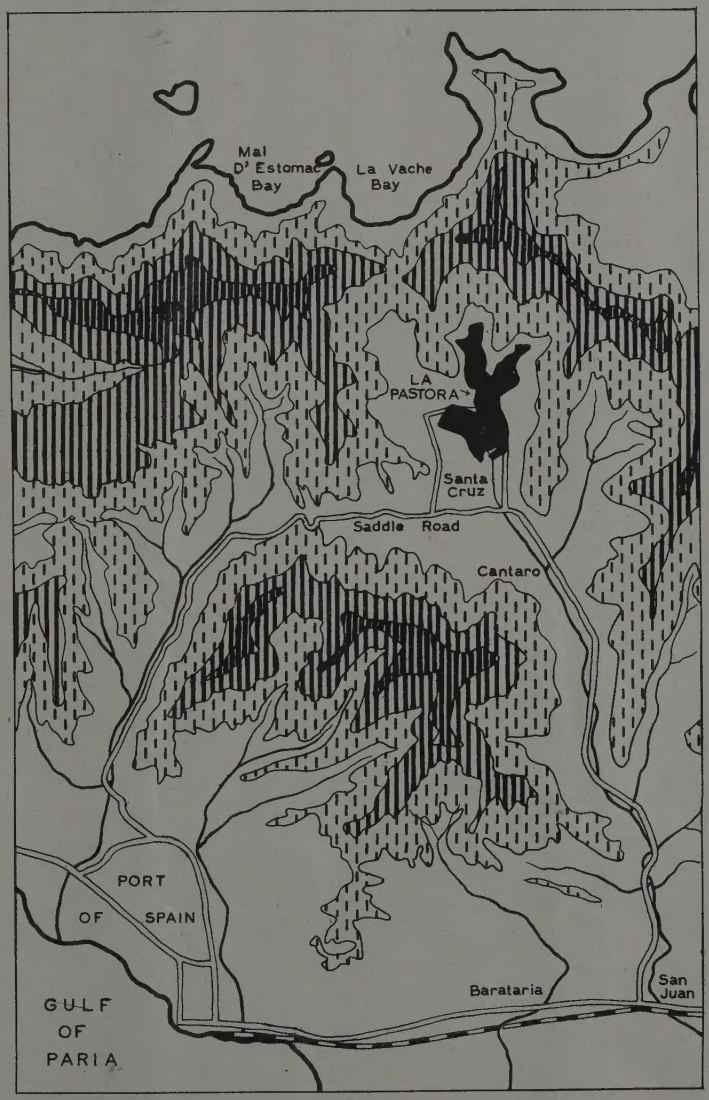
500 – 1000

1000 – 1500

1500 – 2000

OVER 2000

LA PASTORA SETTLEMENT



(32 per cent.). The lack of agricultural experience, however, was compensated by the facts that non-agriculturists had more initial capital and could combine their farming with part time work on profitable non-agricultural businesses and trades in which they were previously engaged. The non-agriculturist had more funds with which to grow the more speculative and labour absorbing crops. Thus, it appears from Table 2 that the non-agriculturist actually farmed better in the sense of putting more into the land and obtaining more in total, and per man-day available, from it.

La Pastora gives the young man an opportunity to set up on his own under advantageous conditions offered by the Government. Not only has this opportunity been taken by young men, but it appears from Table 3 that full use has been made of it; the younger farmers secured double the output, and net agricultural earnings of $0.77 more per day, than the older farmers. Fewer young farmers were previously agriculturists and as a result their initial capital and their total earnings (on and off their holdings) were about twice as great as those of the older farmers. The Table shows most strikingly that the younger men have recognised the commercial possibilities of La Pastora and have energetically set about exploiting them; the older men, many of them displaced peasants from the Caura valley, have been more content to continue methods of agriculture practised elsewhere.

Table 3

Comparison of Old and Young Farmers

	Under 40 Years of Age	40 Years and Over	All
Number of Farmers ..	20	24	44
Agricultural Income per Holding	$950	$476	$691
As % of Total Income ..	68	53	63
Agricultural Expenditure per Holding	$376	$150	$253
Net Agricultural Earnings per Man-day available	$2.56	$1.79	$2.13
Total Income per Total Man-day	$2.55	$1.38	$1.87
Persons in Family (Consumer Equivalents)	3.15	2.81	2.96
Initial Capital	$440	$210	$316
% of Farmers previously Agriculturists ..	30	50	41

The average size of family was about 4½ persons, 2½ being workers and 2 children; converted to consumer equivalents, these numbers give an average family of very nearly 3 consumer equivalents, 70 per cent. of whom were workers. 40 per cent. of the workers' time was available for the holding, 30 per cent. was spent in work off or not connected with the holding, while the remaining 30 per cent. was accounted for by housework and sickness. Of the time available for the holding, 84 per cent. was contributed by men and youths; about one-fifth of the time of women and girls was spent in field work.

The average number of man-days available for the holding was 240 or 112 per cultivated acre; this latter figure was more than double the time available per ratoon cane acre in Bejucal (47 man-days), and thus higher than that calculated to be available for any crop in that area. At La Pastora the number of man-days available for the holding (in common with many other factors) was very variable; one holding had only 64 man-days available or about one-fifth of one man full time; another had 520 man-days available or about 1⅔ men full time. The high variation was due to the different types of farming pursued and to the employment of labour by some farmers.

Income and Standard of Living

The average income per family, exclusive of capital improvements, was $1,102; capital improvements or unrealised income amounted to an additional $115 per family (Table 4). The average income agreed remarkably with that of a

Table 4

Sources of Income, ($ per Holding)

	Cash	Consumed in House hold	Utilised on Holding	Total
Agricultural:				
Water Cress ..	107	2	—	109
Vegetables ..	142	15	5	162
Grains	—	1	4	5
Starchy Roots ..	80	20	9	109
Tree Crops ..	46	13	—	59
Crop Income ..	375	51	18	444
Livestock ..	113	6	—	119
Livestock Produce ..	111	11	6	128
Total Agricultural	599	68	24	691
Other:				
Wages, Peasants ..	10			10
Wages, Estates ..	20			20
Non-Agricultural Employment ..	163			163
Profits from Business	218			218
Total	1,010	68	24	1,102
Changes in Capital Values:				
Crops				+180
Livestock ..				−54
Building Equipment				−10
Savings				−1
Total Improvements ..				+115

very different population in Bejucal ($1,250 per family) and indicated that the La Pastora settler was (at least at the present time) able to make an adequate livelihood off his restricted acreage. This total income averaged $1.87 per total man-day (*i.e.* including the time of housewives and all other potential workers in the family) or $370 per consumer equivalent (including children). Because of the smaller average family in La Pastora, these levels of income were somewhat higher than in Bejucal.

The expenditure on personal items amounted to $494 per family or $168 per consumer equivalent per annum. About three-quarters of this expenditure was for food.

A very low proportion of the food consumed was produced on the holding: only 10 per cent. compared with 50 per cent. in Bejucal; the difference was due mainly to the fact that La Pastora peasants grew no rice. There was evidence of little real poverty in the settlement, or for that matter of extravagant living; 23 families had a personal expenditure of between $100 and $200 per consumer equivalent. Table 5 shows that even large families were adequately though modestly maintained from the workers' earnings.

Table 5

Size of Family and Personal Expenditure

Size of Family Consumer Equivalents	Under 2.0	2.0 to 2.9	3.0 and over	All
Number of Families ..	14	10	20	44
Total Personal Expenditure per Family	$285	$363	$706	$494
Food Expenditure per Consumer Equivalent	$160	$111	$112	$119
Food as % of Personal Expenditure ..	79	73	69	71

The settlers derived 63 per cent. of their income from their holdings. The remarkable feature of the income derived from other sources was the small proportion derived from wages of agricultural employment; employment of settlers as agricultural labourers yielded only 3 per cent. of their total income or 7 per cent. of the income earned away from the holding; about two-thirds of this agricultural employment was given by estates and one-third by other peasants; (in Bejucal 17 per cent. of the total income was derived from agricultural wage earning off the holding).

The fact is that opportunities for agricultural wage earning were much smaller at La Pastora than Bejucal. The nearest estates, on which the employment of labour has been constantly declining, were a mile or more distant from the settlement and were more conveniently supplied with labour from the villages of Cantaro and Santa Cruz. The position with regard to the employment of settlers by their neighbours was rather different and requires some explanation.

Large amounts (total $5,710) were spent by some peasants for wages, although settlers themselves received little of it ($440). But employment of labour was by no means universal and actually more than half the labour expenditure was incurred by nine peasants specialising in cress growing; the bulk of the remainder of wages was paid for vegetable cultivation. On the other hand, more than half the wages were earned by peasants growing mainly Starchy Roots, Plantains and Bananas ("Old System" farmers). There seems evidence, therefore, to corroborate the explanation of labour-employing peasants that they did not employ their neighbours, because they were untrained for the type of work required; it would of course be far easier to train a hired stranger to special work than a permanent and partly independent neighbour.

The general position regarding income was therefore that about two-thirds was obtained from agricultural and one-third from non-agricultural occupations. These percentages were not unduly weighted on the side of non-agricultural employment when it is remembered that the majority of the population was not traditionally agricultural. Indeed, considering the small acreage of their holdings, it would seen that these settlers have concentrated their attention on farming rather than other activities to a commendable degree.

Of the agricultural income, 86 per cent. represented cash sales, 10 per cent. was consumed in the household and 4 per cent. utilised on the holding (fed to stock, kept for seed, etc.). The income from crops amounted to two-thirds of the total, that from livestock and livestock products to one-third. Almost one-half of the livestock sales consisted of capital realised, the sales being mostly of goats and pigs. The reasons for these sales were the extreme difficulty of obtaining regular supplies of feeding stuffs and the impossibility of allowing these stock to forage for themselves on a fully planted holding.

The largest single crop was water cress which contributed 25 per cent. of the crop income. Tree crops (Plantain and Bananas) were about half as important as water cress. Various vegetable crops* ranging from highly cultivated cabbage and cauliflower to almost wild crops of pumpkin and cucumber contributed 36 per cent. of the crop income; starchy roots † contributed 25 per cent. Grains were a small crop consisting almost entirely of corn; pigeon peas did not grow well on the settlement.

* Vegetable crops in approximate order of popularity: Pumpkin, Tomato, Cabbage, Cucumber, Christophene, Pachoi, Melongene, Ochroe, Lettuce, Pepper, Chives, String Beans, Radish, Carrot, Cauliflower.

† Starchy Roots in approximate order of popularity: Cassava, Dasheen, Tannia, Yams, Eddoes.

It will be seen later that the average cropping did not apply uniformly over all holdings; there was a wide difference in the importance of different crops from one holding to another and holdings appeared to fall into a number of dissimilar groups. On the average these peasants achieved a good crop income of $210 per cultivated acre; prices of all produce were high during the year, but this income was twice that obtained by Bejucal peasants under similar price conditions a year previous. It is impossible to show the income per acre from individual crops because it was exceptional (excluding water cress) for any crop to be planted on a separate plot of land, and even where this practice was pursued, it was usual to take more than one crop from the whole or part of the land during the year. The more usual practice was mixed cultivations of three or as many as twelve different crops scattered in varying proportions over the whole cultivated area.

It has been noted that a sum of $115 per holding was estimated to be earned from capital improvement of the holding. This net total improvement was the result of increases in capital value of crops and decreases in livestock, buildings and equipment. The decreases, averaging $65 per holding, consisted mainly of sales of livestock, pens and sties being sold or depreciating when stock were disposed of. The increase in the value of the crops was an estimate by the settler and represented the increase mainly due to clearing and planting. About two-thirds of this net capital increase was achieved by the settlers' own labour; about one-third was achieved by cash expenditure (*see* Expenditure, Table 6).

Agricultural Expenditure

The high agricultural income was obtained in return for a high expenditure of $250 per holding. This sum represented no less than $120 per cultivated acre and is more than double that recorded in Bejucal ($49 per acre). All land in La Pastora was rented and rents alone amounted to $45 per holding or 18 per cent. of the agricultural expenditure. Rent averaged $18 per acre overall, but this included the rent of a substantial house. The rent was nominally divided between house ($33 per holding) and land; on this basis the land rent was very cheap at $5 per acre per annum.

It is becoming apparent that in most peasant farming districts in Trinidad some farmers employ appreciable hired labour: in Bejucal one-half of the agricultural expenditure was for labour; in La Pastora a similar proportion was found. At La Pastora labour expenditure amounted to $129 per holding or $63 per cultivated acre; only 1 per cent. of this labour was on a wageless exchange basis. These averages underestimate expenditure on labour per holding since 12 farmers employed none; the remainder spent an average of $180 each.

The third largest item of expenditure was for feeding stuffs, half of which was purchased* and half home-grown; feeding stuffs amounted to $39 per holding or $23 per cattle unit per annum. This expenditure was about five times that in Bejucal and reflects the higher standards of feeding, lack of grazing and absence of cheap fed oxen at La Pastora. Almost one-half of the purchased feeding stuffs, all of which were in short and irregular supply during the year, was locally manufactured coconut meal. Home-grown feeding stuffs consisted mainly of corn for poultry and starchy roots and damaged bananas for pigs and poultry. It is impossible to estimate the value of grazing, cut grass and green meat consumed by stock but with the small acreages available these foods must have been very limited.

Table 6

Agricultural Expenditure ($ per Holding)

	Purchased	Produce	Total
Labour	128	2	130
Manure	9	6	15
Seed	9	1†	10
Feeding Stuffs ..	21	18	39
Agricultural Supplies ..	4	—	4
Rent	45	—	45
Miscellaneous ..	10	—	10
Total	226	27	253
Capital Expenditure:			
Crops	5		5
Livestock	11		11
Buildings and Equipment ..	13		13
Savings	12		12
Total Capital ..	41		41

† Excludes home-grown slips and suckers used for propagating plantain, bananas and starchy roots.

The expenditure on manure was exceptionally heavy for peasants; the total of $677 or $15 per holding represented only manure applied in controlled quantities to specific areas; large amounts of home produced pen manure were also scattered haphazard among crops adjacent to the house. The recorded expenditure on manure represented overall $7.40 per cultivated acre (pen manure was valued at an average of $1.20 per ton); the manure was not, however, distributed evenly since nine cress farmers, farming 20 per cent. of the land surveyed, applied nearly three-quarters of the total manure. Four-fifths of the manure was

* Purchased feeding stuffs in order of popularity: Coconut Meal, Proprietary Chick Feed, Oats, Bran and Pollards, Damaged Flour, Molasses, Linseed Meal, Corn, Rice Bran, Proprietary Poultry Feed, Soya Bean Meal.

organic, almost exclusively cattle manure, half of which was purchased. The only inorganic manure applied was Sulphate of Ammonia.

Live and Dead Stock

The rate of stocking at La Pastora was about twice as heavy as in Bejucal; at La Pastora 0.8 cattle units were carried per cultivated acre, or about 1.7 per holding. The composition of the livestock population was noticeable for the lack of draft animals; only one-tenth of the total cattle units consisted of draft animals and all of these were equines. Draft animals were used exclusively for road work and no animal drawn implements were employed in the field. The holdings offer no opportunity for animal powered cultivation since the only crops that require periodic tillage (cabbages, melongene, etc: in pure stand), were grown on very small areas of a few "beds' in extent.

The other characteristic of the livestock population was the large numbers of small stock, chiefly poultry, pigs and goats. It is true that cattle comprised nearly half the total cattle units, but 28 farmers had no cattle at all. Of the small stock, poultry contributed more units than other classes and numbered in all about 1,000 head. East Indian farmers kept 70 per cent. of the cattle and virtually no pigs. The Spanish Indians owned the smallest number of stock of the racial groups, but had an average of about 1⅛ units per holding.

The value of livestock averaged $240 per holding or $142 per cattle unit; this value represented 83 per cent. of the total valuations of live and dead stock.

The deadstock investment amounted to $50 per holding: one-third of this was equipment for livestock (carts, pens, hen houses, etc.). The largest single item of equipment was bicycles which also amounted to about one-third of the deadstock total. Implements and tools averaged only $8 per holding or 15 per cent. of the total. Cultural implements consisted entirely of forks, hoes and cutlasses; some farmers growing intensive vegetable crops had invested in sprayers and dusters.

Variability of Data

These average figures have been given to describe the general position at La Pastora; however, they do not indicate the extent of variation, which was in fact very wide. For instance, the total income varied from $146 to $4,000, the agricultural income (excluding improvements) from $59 to $3,000 per holding and the crop income from $27 to $1,057 per cultivated acre; one-quarter of the farmers had a total income of less than $420 per annum, one-quarter had an income over $1,500. The agricultural expenditure varied from $31 to $1,890, one-quarter of the settlers spending less than $100, one-quarter more than $300. The valuation of livestock varied from $7 to $1,560, the lower and upper quartiles being $50 and $500 respectively. And so on.

These variations may at first sight appear surprising, especially when it is remembered that all holdings were restricted to about 2½ acres each. The variations must, therefore, be due more to differences in types of farming than differences in area size.

On closer consideration, a variation in type of farming is to be expected under La Pastora conditions. The small area of land made it impossible to make a living at some uniform minimum type of farming and as there was no established peasant area in the district, there was no recognised system of farming. Then, the fact that the settlement had been functioning only three years meant that settlers were still in the transition period of "getting on their feet" and had not yet achieved the final system they hoped to pursue; other farmers with sufficient capital had been able to launch out right away in a high input-output type of farming. Finally the method of selecting settlers had resulted in a variation in the people themselves; a variation not only as to race, size of family, etc. but also as to inherent ability and enterprise.

It is desirable, therefore, to attempt to split the sample into more homogeneous groups. Several classifications were considered but the soundest in the end appeared to be according to rather arbitrary farming types. The fact that 44 farmers have been split into as many as five groups need not necessarily detract from the comparisons; it is much sounder to compare nine or even six farms that form distinct agricultural types than to compare 20 which are very heterogeneous within each group.

(To be concluded.)

CACAO ECOLOGY

At a joint meeting held in London by the Royal Meteorological Society and the British Ecological Society, a paper was read entitled "Climate within a Tropical Rain Forest", by Dr. G. C. Evans and Dr. P. W. Richards. The observations brought forward were made in British Guiana. Tropical rain forest consists of several stories, of which the lowest is the most dense. The data were collected at two contrasting points, one within this lowest story and one in the upper canopy of the forest. The most interesting point related to the humidity of the air. This is continuously high at the lower station, being always very close to saturation point; it is, on the other hand, very variable in the upper canopy. This is of considerable ecological interest as reflecting one aspect of the climate within which the smaller trees of such a forest grow; it is also of importance in connexion with those plantation crops, such as cacao, which naturally occur as under-story trees and so need the type of climate which occurs under the protection of a high canopy.—(*Nature, Vol.* **157**, p.828).

SUGAR CANE MOSAIC IN JAMAICA

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History

Sugar Cane Mosaic was first recognised in Jamaica by Dr. Lyon when visiting the island in January 1920 (Nowell, 1923; Hansford, 1926), and it was then found to be generally distributed, indicating that though not previously recognised, it had been present for some years. It is worth comment that attention was drawn to the disease first when a visiting scientist recognised the leaf symptoms on cane at Hope Experiment Station, not as a result of complaints by planters of a strange new disease affecting their cane.

Most of the varieties cultivated at that time were susceptible to the disease, the recognition of which then caused considerable alarm to the cane planters. The Department of Agriculture, however, inaugurated a control campaign on the generally accepted lines of roguing, accompanied by the use of immune varieties, and there is no evidence that the sugar industry suffered subsequently to any very serious extent from the disease, though it must be remembered that at the time rum was of more importance to Jamaica than sugar.

In the 'twenties' the immune variety generally favoured was the thin stemmed Uba, but this was replaced in the early 'thirties' by the higher yielding POJ varieties, and amongst cane farmers these latter are even today widely cultivated. The variety BH 10/12 was extensively planted from around 1925, and still occupies a large though dwindling acreage (Report of the Sugar Industry Commission, 1944-45). It was very susceptible to mosaic, but where desired, it was possible by application of control methods to reduce the percentage of the disease in it to a relatively small amount.

In recent years new seedlings have been introduced from the West Indies Central Sugar Cane Breeding Station in Barbados, of which the tolerant B34104 and the resistant B3439 have been extensively planted, and other varieties are under trial and in the early stages of extension.

Differences in the apparent effect of the disease in separate areas of the island, conflicting results in comparing degrees of resistance of new seedlings to mosaic in Barbados and Jamaica, and a variety of symptoms suggesting that there might be more than one type of mosaic in the island, resulted in an investigation carried out by the writer at the request of the Sugar Manufacturers' Association.

Mosaic in Jamaica at the Present Time

Visits were paid to 22 out of 26 Estates, inspections being made at least twice in each case, once in the "summer" and once in the "winter". Mosaic was found to be widespread throughout the island, and no estate is free of the disease entirely, though several have complete 'commercial' control, the amount of the disease being well under one per cent.

Assessing the extent of mosaic and the damage caused thereby with any degree of accuracy would be extremely difficult. As regards the extent of the disease, estates are divided up into sections, and it is often the case that the percentage of mosaic varies considerably from one section to another, and even from field to field. Anything approaching an accurate figure can only be given where roguing is conscientiously carried out and proper roguing counts kept, and this only applies to one or two areas where the disease is under thorough control.

It has been noted on several estates that mosaic is worst in its effects on poor soil, and is more difficult to control under such conditions, a difficulty which can of course be overcome by planting resistant varieties in these areas. It has not yet been determined to what extent, if any, secondary infection plays a major part on these occasions.

As regards the damage caused by the disease, this is an even more debatable point. (1) Hardy (1945) has drawn attention, with regard to soils, to the many interrelated factors concerned which affect the final yield of cane-sugar 'in the bag', the relative importance of each of which still remains to be ascertained. Similarly, infection of a cane plant by mosaic disease is only one factor among many, the exact effect of which it is difficult to evaluate individually. In Jamaica certain estates with large acreages of BH 10/12 for years disregarded mosaic, despite a very high percentage of infection, and claimed to have no abnormal losses in their ratoon crops (generally carried on for three or four years, but sometimes longer). This claim was supported by their annual returns. On the other hand, the symptoms of mosaic on BH 10/12 are often very apparent, including shrinkage and splitting of the stems, which must inevitably cause a loss of sugar.

The position until recently therefore was that most estates grew a high proportion of BH 10/12, which they rogued with a varying degree of thoroughness, largely according to the amount of damage they considered was done by mosaic. Some had good commercial control throughout. Others rogued plants and not ratoons, and a few did not rogue at all. In cases where properties

(1) The Sugar Research Office of the Sugar Manufacturers' Association intend to carry out a statistical trial to try and obtain evidence as to differences in yield between mosaic infected and healthy cane of the tolerant B34104 and the susceptible BH 10/12 varieties.

wished to avoid the disease and could not obtain control by roguing, they resorted to resistant varieties, and this largely applied to those in dry, non-irrigated areas, where the question of roguing is complicated by the difficulty of getting 'supplies' to take root if the short rains of the planting season are over, for which reason such estates carry on ratoons much longer than in wetter areas and seldom replant a whole field at a time.

Cane farmers either used resistant varieties, or reaped their mosaic infected canes for what they could get from them, few troubling to rogue. In peasants' gardens there can still be found some of the old and highly susceptible varieties that were in vogue twenty to thirty years ago.

In the last few years however a new factor has been introduced with the introduction and increasing popularity of the tolerant variety B34104. This was found to be extremely susceptible to mosaic in Jamaica, but though leaf symptoms appear, the cane itself seems generally unaffected. Unfortunately the leaf symptoms, often not very distinct on this variety, may vanish almost entirely as the cane matures, so that 'tops' considered clean, but actually infected, are used for planting. Furthermore, in the desire to extend so valuable a cane large numbers of tops have often been taken from fields known to be diseased, but owing to the tolerance of the variety no insistence was laid on clean planting material. As a result, many properties have their acreages under this variety almost 100 per cent. infected, although on others, where proper precautions have been taken, commercial control has still been obtained. The danger lies in the fact, however, that should properties allow themselves to become planted chiefly to tolerant varieties that are all heavily infected, they will be seriously handicapped should a promising susceptible variety appear, which could be extended and kept clean on a property where the disease was under control, but might be difficult to manage if closely surrounded by heavily infected cane.

Secondary Infection

This brings us to consideration of the transmission of the disease by insect vectors, a problem which needs further entomological study in Jamaica. From general observations it would appear that insect transmission is not a factor of major importance, which agrees with recent observations in India (Chona, 1944) where the vector has yet to be found, and in Louisiana (Ingram *et al.* 1939) where difficulty was experienced in accounting for any extensive spread of the disease by the only proven vectors.

It is generally considered that sugar cane mosaic is transmitted in the West Indies by the corn (maize) aphis, *A. maidis* Fitch (Smith, K., 1937), and as the disease also occurs on corn (*Zea mays L.*) and Guinea Corn (*Sorghum vulgare* Pers.), on both of which the insect feeds legislation was introduced in Jamaica soon after mosaic was recognised to prohibit the growth of these susceptible crops near to cane, and also to enforce roguing of mosaic infected cane under certain conditions. Such legislation, somewhat modified, is nominally in force at the present time, but in actual practice its enforcement is extremely difficult in a country where corn is an important crop and where the opinion of sugar planters as to the importance of roguing mosaic is so far from unanimous.

In practice, however, a degree of control is often obtained by insertion of a clause in tenancy agreements concerning land adjoining sugar estates, forbidding the planting of corn or guinea corn thereon.

As already noted, it is apparent that secondary infection is by no means widespread or inevitable, and many cases have been noted in observation plots where susceptible canes have grown alongside infected canes for months without taking the disease. In fact so small was the rate of secondary infection in the Department's experimental fields at Hope, where mosaic has been in existence for years, that the experiments described in the latter part of this paper were carried out successfully without the use of cages.

Occasional bad outbreaks of mosaic on clean cane can probably be correlated with some temporary conditions especially favouring the appearance of vectors and of secondary infection, and which are more liable to occur in some areas than in others. It is also possible that further investigation may yet reveal the presence of other vectors.

Symptoms on Cane in Jamaica

The symptoms of mosaic vary in intensity with the age of the cane, the season of the year and the conditions under which the cane is growing. In Jamaica, however, there are three main types which may in general be distinguished as follows, although symptoms are sometimes observed bordering between marked mosaic of type (*a*) and mild mosaic of type (*b*).

(*a*) *The 'green' type.*—This, the mildest form of mosaic, is found on the 'tolerant' varieties such as B34104, B37161 and a number of the more recent Barbados seedlings. In B34104 it consists either of islands of lighter green on a darker green background, or *vice versa*, and in B37161 may be no more than small darker green streaks in a lighter green background. The disease in fact has little effect on the chloroplasts, and as a rule the difference in the shades of green is slight, often making this type of mosaic difficult to see without fairly careful inspection. The canes that suffer from it have not been observed to show any stem symptoms, occasional shrinkage of stems noticed in B34104 never being universal over any extensive area, and probably being attributable to other factors affecting the cane.

(*b*) *The yellow 'mottled' or 'stippled' type.*—This is found on the susceptible canes such as BH 10/12, and also on resistant varieties, and is more variable than type (*a*). The

symptoms involve yellowing of the leaf to varying extent, indicating an effect on the chloroplasts. For BH 10/12 the symptoms may be described as an alternation of lighter and darker green as described above for B34104, but accompanied also by yellow or yellow green flecking, which gives the yellowish appearance to the leaf as a whole. Stem symptoms also appear to varying extent on the susceptible varieties, and in BH 10/12 appear as reddish streaks on the cane, and shrinkage and splitting of the joints. Badly mosaic infected cane is troublesome in the mill.

(*c*) *The yellow 'blotchy' type.*—This is found on the resistant B3439 and on one or two other of the Barbados seedlings. In B3439 the leaf symptoms appear as elongated islands of yellow green which show up in marked contrast to the normal darker green of the rest of the leaf. Generally one or two shoots in a stool are affected, but these are often markedly stunted and may die back altogether. The symptoms are so noticeable that roguing is easy.

In addition to the above three general types of mosaic, symptoms were observed on one stool of B34104 of what was apparently a quite distinct mosaic, which is described below.

Identity of the above Described Symptoms

In view of the 3 different variations in symptoms described above under types (*a*), (*b*), and (*c*,) planters felt that there might be different varieties or strains of mosaic in the island, and it was desired to obtain definite proof as to whether this was the case or not.

A collection of specimens of mosaic infected cane was planted at Hope, including all the recognised variations in leaf symptoms. A few canes submitted with symptoms thought to represent unusual forms of mosaic were found in fact not to be affected by virus, and produced healthy progeny, the suspicious symptoms on the parent having been due to some other causes.

The collection included the following mosaic infected canes :—

Type (*a*) B34104
B37161
B726

Tye (*b*) BH 10/12
EK28 ....Very marked symptoms
CO419
SC124
FC916 ...A resistant variety, very mild symptoms
B35245
Bourbon ....Very susceptible

White Transparent
Craw Fish
Ribbon Stripe
Mexican Stripe
Ba11569
B3539
} 'Sports' of White Transparent. } Canes grown on peasant holdings.

Type (*c*) B3439
B39199
B4097
B40114
B41228

For purposes of comparison the following canes were used as standard varieties, BH 10/12, B34104, B3439 and B37161. Adjoining plots of 24 plants, of each of these, spaced 5′ × 4′ were planted, and in addition plants of these varieties were raised in pots.

Cross inoculations were then carried out between the standard varieties, and also from various mosaic infected canes in the collection on to the standard varieties, to see whether the inoculations resulted in reproducing the symptoms normal for the standard variety in question or those of the type used for inoculation.

In every case the symptoms arising on the standard variety as a result of inoculation were the same as those normally associated with this variety, and there was no unusual effect noticeable in the stems. It was therefore assumed that *only one variety of mosaic occurs generally in Jamaica, causing different symptoms, however, according to the variety of cane affected and the circumstances of season and environment.*

Details of these inoculations are shown in Table I.

Table I

Mosaic infected canes used as source of inoculation		Standard Canes							
		B34104		BH 10/12		B3439		B37161	
		'Takes'	Failures	'Takes'	Failures	'Takes'	Failures	'Takes'	Failures
Type A	B34104	—	—	14	0	5	16	7	11
	B726	—	—	—	—	—	—	1	5
Type B	BH 10/12	33	6	—	—	5	21	8	19
	SC124	10	0	—	—	—	—	2	2
	Bourbon	13	3	—	—	0	10	1	3
Type C	B3439	14	2	7	3	—	—	3	2
	B4097	2	0	2	0	2	9	—	—
	B40114	7	6	6	1	—	—	—	—
		79	17	29	4	12	56	22	42

Inoculation Technique and Notes on Various Experiments

The inoculation technique used throughout was the Sein leaf Slip method employed in Barbados, as described by Stevenson (1939), consisting of tightly rolling a strip of mosaic infected leaf round the 'spindle' of the plant to be inoculated and pricking through both with a bunch of fine needles. The Matz method was also attempted, but unsuccessfully, as had been the case in Barbados (Stevenson). Attempts to transmit the disease by cutting the ends of young leaves under the surface of sap squeezed from mosaic infected tissues were also unsuccessful.

The method of inoculation served the purpose in the investigations under discussion, and gave a high percentage of 'takes' where susceptible canes were employed, a lower percentage resulting when resistant canes were used. It is however inherently crude, as small variations in manipulation, both between similar operations conducted by the same individual, as well as between similar operations by different individuals, allow of inconsistent results, and there is no means of regulating the 'dose'.

The use of an inert oil, and retention of plants in a damp chamber before inoculation, as advocated by Innis (1944), were tried. Oil applied at the point of inoculation was found to be of no great value. In an experiment in which plants were kept in a damp glass house for 48 and 24 hours respectively before inoculation, as compared to others brought straight from the nursery, those kept for both one and two days in the damp tended towards a higher percentage of 'takes', as shown in Table II.

These results, which incidentally indicate the inconsistencies referred to above, were not pursued further, but as a general practice plants in pots were kept at least 24 hours in a damp green house before inoculation.

Cross Inoculation Experiments

These were carried out using the above described technique and with the results shown in Table I. After inoculation, mosaic symptoms appear as a rule at the bottom, and sometimes on one side only of a fully open leaf, then at the bottom, sometimes on one side only and sometimes both, of the next leaf to open, after which the leaf unrolling from the spindle shows symptoms throughout. The length of time taken for the first symptoms to appear after inoculation varies considerably, the rate of growth of the cane being of course the important factor. Day to day observations were not made, but susceptible varieties generally began showing a number of 'takes' in the third week, though appearance of symptoms might be delayed for a month to six weeks.

In the case of the resistant variety, B3439, several instances were observed in which only one or two leaves of inoculated plants showed symptoms of the disease, subsequent leaves developing without them, or in which one or two shoots only of an inoculated stool became affected, remained stunted, and finally died, while the rest of the stool developed normal healthy shoots.

Cross Inoculation between Corn and Sugar Cane

Attempts were made to trasmit mosaic, using the same technique as described above, from corn (*Zea mays* L.) to cane, from cane to corn, and from corn to corn, without success. The nature of the corn leaf would appear to be unsuited to this technique.

Inoculation between Cane and Grasses

It has been suggested from time to time that some of the common weed grasses of sugar estates may carry sugar cane mosaic without showing the symptoms, and form a source of reinfection for clean cane. Clumps of Guinea grass (*Panicum maximum* Jacq.) and Para grass (*Brachiaria mutica* Stapf.) were planted in pots, and 47 shoots of the former and 53 of the latter inoculated with mosaic infected BH 10/12. After an interval of 17 days, young leaves of the inoculated grass plants were in turn used to inoculate BH 10/12, B34104 and B37161. No symptoms of mosaic were produced, but the value of the experiment is vitiated by the failure of the technique in attempting to inoculate corn, and the consequent uncertainty of its efficacy when applied to these grasses.

Appearance of Mosaic on Shoots from Infected Cane (Primary Infection)

In canes planted from infected 'seed', and kept under observation, it has sometimes taken 3-4 months before the symptoms of the disease appeared on the resulting stools.

Also, plants of BH 10/12 have been inoculated as single shoots, and in the resulting stool one or two clean shoots have appeared and remained clean for a year.

Table II

	Number of 'Takes'			
	BH 10/12	B34104	B3439	Total
Two days in damp green house	11 out of 12	4 out of 6	5 out of 7	20 out of 25
One day in damp green house	10 out of 11	6 out of 6	2 out of 8	18 out of 25
Taken straight from nursery	6 out of 11	3 out of 6	2 out of 8	11 out of 25

Observations in the Field

Mosaic on BH 10/12.—On one property BH 10/12 on badly drained clay soil was very markedly affected by mosaic, which was fairly general throughout the property. The stems of cane were shrunken and the plants were growing poorly. Tops from these however grew in the experimental nursery without producing the excessively marked symptoms, and inoculations from them on to B34104 produced the normal symptoms of the latter variety.

Resistance of B3439.—On the same property, which is in an area where mosaic is plentiful and little roguing has been done in the past, a field was inspected in which B3439 had been interplanted with BH 10/12. The latter, which was 100 per cent. mosaic infected, was ratooning for the third time, the former for the first time. The B3439, despite being surrounded by mosaic infected cane, was entirely clean. Besides emphasising the resistance of B3439, this suggests that in this case at all events there was an entire absence of insect transmission, for the B3439, though resistant, is not immune to the disease.

Mosaic symptoms on B34104.—Owing to the large amount of infection on this variety and its extended cultivation, the writer and officers of the Sugar Manufacturers' Association's Sugar Research Office, in cooperation with planters, have been watching for any cases where this cane might show signs of damage from the disease. In mature B34104, under certain conditions, some splitting of the lower joints and a greyish discolouration thereof can sometimes be observed, on both healthy and mosaic infected stools. Tops taken from mosaic infected cane showing such symptoms were planted at Hope, but the subsequent plants and the first ratoon, although mosaic infected, have not produced these stem symptoms and have shown normal growth.

In one section of one property individual stems in mosaic infected stools of B34104 were observed to show some shrinkage, but the condition did not even extend to the whole stool. Mosaic infected cane of this variety in a nursery on very poor soil on another property showed some shrinkage of the joints. It is however not possible to attribute any general appearance of damage to canes of B34104 from mosaic.

Mosaic on B37161.—This variety, though resistant, is not immune, but generally only shows very mild mosaic symptoms on the foliage. These show up sometimes quite suddenly after rain has promoted growth, and on individual plants may be more marked than on others. Observations on mosaic infected plants of this variety at Hope showed that the symptoms may be present so faintly as to escape a casual observation, that they become more prominent in wet weather and more conspicuous on some shoots than others. As the cane matures, they may again disappear almost entirely. Owing to this habit one or two properties have got a good deal of infection into plantings of B37161 by inadvertently using infected tops.

A New Variety of Mosaic

On one property, during the autumn of 1944, a single stool of B34104 in the middle of a field was observed showing very marked, yellow, mosaic symptoms. The stool was stunted, and an abnormal amount of tillering had occurred. Tops from this stool were planted in the experimental plots at Hope, and later the whole stool was transplanted there.

Inoculations with this mosaic were made on to all the standard varieties, namely B34104, B3439, BH 10/12 and B37161, and plants that became infected were used for repeat inoculations. In all cases the distinctive symptoms of the mosaic variety in question were reproduced. These consisted of islands of dark green tissue in a background of paler green, *i.e.* the greater part of the leaf showed damage to the chloroplasts. During some seasons, the chlorotic areas becomes very marked, giving a conspicuous yellowed appearance to the cane.

To test whether or not these distinctive symptoms were due to a new variety of mosaic, or merely to a different strain of the virus generally present in the island, 12 plants of BH 10/12 and 12 plants of B34104 were inoculated with both normal B34104 mosaic and with leaves showing the distinctive symptoms. On 4 plants of B34104 and 1 plant of BH 10/12, out of a total of 21 'takes', symptoms of both the distinctive variety of mosaic and the normal variety were clearly distinguishable, sometime on individual shoots of one stool, and sometimes on leaves of the same shoot. It was therefore assumed that, according to Bawden (2), the distinctive symptoms were those of a new variety of mosaic, somewhat more virulent in its leaf symptoms than that generally present in Jamaica, and not merely a different strain of it, though this latter interpretation would probably be in accordance with the nomenclature used by some workers on this disease.

Although in this case the new variety was observed, and made the subject of experiment, it is not likely that it would have survived or spread far under natural conditions, as its distinctive appearance would almost certainly have resulted in its removal, and this, together with its inhibitory effect on the growth of the cane would also ensure that tops infected with it were never used for planting.

The sudden appearance of different varieties and/or strains of mosaic has been reported on several occasions by workers who have had mosaic infected canes under close observation.

Discussion

The investigations carried out by the writer dealt with the practical aspects of sugar cane mosaic as it affects the planter in Jamaica. In general the behaviour of the disease was found to

(2) '...it now seems probable that plants infected with one strain of any virus become resistant to infection with other strains of that virus although remaining susceptible to infection with other unrelated viruses'. (Bawden, 1943).

be similar to that described from other countries, and shows many features in common with the experience of workers in Louisiana (Tims, *et al.* 1935), though a more virulent type would appear to exist there. It is apparent that control of the disease in Jamaica is largely a matter of management, and in any case with the increasing use of immune, resistant and tolerant seedlings, the disease does not now constitute the threat to the industry which it did twenty years ago.

The variety of mosaic occurring in Jamaica does not appear to be unusually severe, and the quarantine regulations in force throughout the British West Indies should ensure no new and more serious strain being introduced. The possibility of new varieties of mosaic, such as the one discussed, arising in the island cannot be overlooked, but if of a markedly serious nature they would almost certainly be discovered soon and could be eradicated easily.

The complete eradication of mosaic from Jamaica is almost a practical impossibility, the very fact that its effect is usually so negligible making it extremely difficult to arouse the necessary unanimity of public opinion which would be required to bring about a successful island-wide campaign against the disease, and in any case the cost to the country of such a measure could not be economically justified. The planter must learn to treat mosaic as a chronic disease, endemic to the country, and to be kept in subjection and treated as another one of several factors which tend to keep sugar yields per acre below the optimum.

From the theoretical aspect, there are a number of problems which still need investigation, and although coming individually rather under the head of academic research, the sum total of their solutions might prove of practical value. With regard to varieties or strains of mosaic, it has already been found that those from the Pacific produce different symptoms to those of America (Matz, 1939), and it would be interesting to know if the same variety or strain exists in general throughout the Carribbean, and how this (or these) compare with those recognised in Louisiana and elsewhere. Comparisons of this nature would of course have to be carried out in 'quarantine', as no cane growing country would care to run the risk of possibly introducing a new mosaic into their cultivation. It is possible however that the different showing of resistant cane varieties from Barbados when tested in Jamaica may be due to a difference in strain of the mosaic occurring in the two places. On the other hand the milder effects of mosaic in the South Caribbean may be due to differences of climate and length of day.

The possibility of other vectors, and the factors controlling the origin and movements of the vectors, need further entomological investigation, and a student of plant viruses might be able to throw more light on the behaviour of the Saccharum viruses in the cane plant, and explain why the foliar symptoms of the disease vary so often in intensity, not only with environment and season, but sometimes in individual plants of the same variety, side by side. Do present methods of inoculation inject a 'dose' of the virus that varies considerably, and is the nature of the 'dose' administered reflected in the subsequent effect on the plant? Finally, it has yet to be discovered just what factors contribute to immunity or tolerance in the varieties that show these qualities.

Summary

(1) The history of mosaic disease of sugar cane in Jamaica is outlined.

(2) The present state of the disease in the island is described.

(3) The possibilities of secondary (insect transmitted) infection are discussed.

(4) The symptoms of the disease as they appear in Jamaica are described and proof given of the identity of the virus causing a number of apparently different symptoms.

(5) The inoculation technique used and the nature of the various experiments carried out are described.

(6) Some notes are given of observations in the field.

(7) The discovery of an isolated case of a new variety of Saccharum virus which apparently arose spontaneously is described.

(8) The occurrence of mosaic in Jamaica is discussed in its field aspects, indicating that though its total eradication is not a practical proposition, it no longer constitutes a serious threat to the sugar industry.

(9) A number of problems are indicated, of more academic interest, that still call for elucidation.

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A NOTE ON THE STORAGE OF TRINIDAD GROWN CABBAGES

BY

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Introduction

The 1945 cabbage crop was so heavy that prices dropped to unremunerative levels and the market could not absorb all the cabbages that were ready for cutting. Cabbages were therefore placed in cold storage with the objects of avoiding waste, relieving markets in the interests of growers, and obtaining information as to the possibilities of storing locally grown cabbages in the commerical cold storage accommodation already available in the Colony.

Growth and Harvesting Conditions

Cabbages were purchased from a number of small growers on Aranguez Estate where they had been planted out towards the end of the rainy season on alluvial soil. Urine and sulphate of ammonia had been applied and the beds kept moist by surface watering throughout the growing period. Early Flat Dutch and Succession were the predominant varieties.

The cabbages were cut and purchased in the field on 19th April on a wet day following three weeks of damp weather, and were transported 5 miles to Port-of-Spain where they were selected, stripped and trimmed before being packed in crates. The quantity handled was almost double that for which provision had been made with the result that inspection and selection in the field was less thorough than it should have been; culling, stripping and trimming was correspondingly heavy, reducing the weight by 20 per cent; and 54 hours elapsed from the time of cutting until the last cabbages were placed in cold storage.

Storage Conditions

14,700 lbs. of cabbages were packed unwrapped in 350 grapefruit export crates (Florida bulge pack type) holding an average of 42 lbs. each, and the crates were stacked compactly in a room of 8,600 cubic feet capacity cooled by air blast. At first, much of the remaining space was occupied by other goods but these were later withdrawn and were not replaced.

Conditions in the storage chamber were recorded by thermohygrograph, which revealed that the air temperature fell to 40° F. sixteen hours after the first batch was put in; it was then opened up to put in the remaining cabbages and a further 24 hours elapsed before the temperature again fell to 40°. Thereafter the temperature ranged between 36° and 42° for the first five weeks but was somewhat higher—from 40° to 60° for the remainder of the storage period. Relative humidity was practically 100 per cent. for the first two weeks but fell to 92 per cent. for the next two weeks, then ranged between 82 and 88 per cent.

As this storage trial was financed on a trading account, not with funds provided for experimental purposes, it was necessary to avoid undue risk of loss and to realise as much as possible from sales; decisions with regard to withdrawals from storage and the amount of stripping before selling were therefore based on market conditions. Cabbages were first withdrawn after four weeks storage, the last withdrawals being made five weeks later. Losses in weight during storage and losses resulting from subsequent stripping to prepare the cabbages for sale were as follows:—

Week cabbages were withdrawn	*Loss in weight during storage*	*Weight stripped and discarded*	*Weight sold*
	%	%	%
4th	5	8	87
5th	7	13	80
6th	5	20	75
7th	8	21	71
8th	13	17	70
9th	13	22	65

The relatively lower losses from stripping in the later weeks was due not to less wastage but to improved market conditions as a result of which less attractive cabbages became more readily saleable and further stripping would have reduced the gross return.

The cabbages were unattractive in appearance when withdrawn from cold storage, the outer leaves being wilted and brownish, but the hearts were sound and in good condition. As the period of storage lengthened, deterioration extended more deeply into the cabbages and progressively heavier stripping of waste leaves became necessary to expose the sound hearts.

Financial Returns

The financial results of this storage trial are shown below :—

The cost of labour was higher than it should have been, due partly to unnecessarily heavy stripping before storage and partly to the payment of overtime rates to complete storage before the week-end ; on the other hand, crates were borrowed and therefore cost nothing. Cold storage charges, which were payable monthly in advance, were equivalent to 60 cents per 100 lbs. cabbages for a month or part of a month.

Conclusions

With the experience gained it is now considered that less than 10 per cent. of the original weight would be lost before storage and that the nett saleable weight would decline at the rate of about 5 per cent. per week. Total costs under existing local conditions would be about $1.50 per 100 lbs. to the end of the first month, with a further 60 cents per 100 lbs. becoming payable at the beginning of each subsequent month. In other words, cabbages worth 5 cents per lb. originally would have to realise about 8 cents during the first month and about 12 cents during the second month to cover all expenses. But the gain to growers in the form of profit on cabbages stored would be greatly exceeded by the gain on the remainder of the crops which could be sold fresh at higher prices as a result of healthier market conditions. In this particular instance, the storage of mature but unwanted cabbages relieved the market to such an extent that a completely stagnant market changed to quite a healthy one and prices to growers increased 100 per cent. within two weeks.

While the cold storage of seasonal surpluses would benefit consumers by extending the period over which good cabbages would be obtainable, it would be of greatest benefit to growers, and efforts are therefore being directed to the establishment of a marketing co-operative of growers to regulate the sale and, where necessary, the storage of its members' cabbages.

Financial Returns

Receipts	$ c	Expenses	$ c.
Proceeds from sales of cabbages :—			
271 lbs. @ 5 cents	13 55	Cost of 18,410 lbs. cabbages @ 6 c. ...	1,104 60
41 lbs. @ 6 cents	2 46	Labour	109 65
13 lbs. @ 8 cents	1 04	Cold Storage Charges	144 72
2,931 lbs. @ 12 cents	351 72	Excess of receipts over payments ...	230 54
2,751 lbs. @ 14 cents	385 14		
2,520 lbs. @ 15 cents	378 00		
2,860 lbs. @ 16 cents	457 60		
	$1,589 51		$1,589 51

A NEW METHOD OF MAIZE IMPROVEMENT

(*The following addendum has been submitted by the author to the article published on the above subject in the June* 1946 *issue of this journal and which appeared on page* 114.)

Since the article on the above subject was written I have come across a reference which indicates that the idea of crossing desirable plants in pairs is not new. In the Year Book for 1937 of the United States Department of Agriculture (page 466) appears the following statement :—

"About this time (1868) A. E. Blount began controlled pollination in a variety of white corn. The ear shoots of 100-300 desirable plants were covered with muslin each season. These selected plants were hand-pollinated with pollen of other desirable plants selected as male parents. The resulting variety called Blount White Prolific, came to the attention of the Rural New Yorker about 1879 and was widely distributed by them."

It appears however that Blount did not test the paired crosses to see which were the most productive, but mixed all the crosses together.

The writer's results shew that many paired crosses give yields below the average of the original commercial variety, and since Blount's method made no attempt to separate the superior combinations from the inferior, the method described here may still be regarded as original.

S. C. Harland

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FERTILIZERS EXPERIMENTS ON GRAPEFRUIT IN JAMAICA

A Report on the Results of Field Experiments on the Effects of Fertilizers on the Growth, Yield and Quality of Marsh Seedless Grapefruit grown on the Main Citrus Soils of Jamaica and on the Uptake of Plant Food Elements by the Fruit and the Leaves, A Summary, 1936-46

BY

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The Agricultural Chemist's Division has carried out experiments on the fertilizer requirements of grapefruit for the past ten years and the work is at present in the process of being written up. Summaries and interim reports have appeared regularly in the annual reports of the Department.

The citrus soils of Jamaica range over extremes of type, from deposits of iron and aluminium oxides without any clay material, through sandy loams and loans (mainly of recent alluvival origin) to heavy clays of the Inland Basin type. From an analysis of the soils it is very evident that extremes in plant nutritional status occur, some soils showing pronounced deficiencies in potash, some in phosphates and many in both. Futhermore, from considerations of chemical composition and soil reaction, it is equally evident that the so called micro-elements may be of limited availability on many citrus soils.

The major experimental work was carried out at Grove Place and Wakefield (in St. Catherine) on Marsh seedless grapefruit budded on sour orange. The choice of experiment sites has been fortunate in that extremes of soil conditions have been covered. At Grove Place, the soil is rich in phosphates and lime, and slightly alkaline in reaction but deficient in potash. It is typical of a large area of citrus land on Terra Rossa. The Wakefield soils on the other hand are extremely acid, low in lime status, and deficient in both phosphates and potash. The experiments were all laid out according to the most recent statistical design of the day and the results are all derived with certain known probabilities. From a combination of the data obtained from the two sites it is hoped to obtain the basic data upon which to build up a reliable citrus fertilizer advisory service for major plants foods, N, P and K.

The data recorded from which conclusions will be drawn are as follows :—

a. The size of the trees as determined by trunk size, the height and breadth of the canopy.
b. The relative response of stock and scion to fertilizers as indicated by the girth above and below bud unions.
c. The yield of fruit by weight and numbers.
d. The grading of the fruit by recognised sizes.
e. The percentage of fruit dropped prematurely.
f. The quality of the fruit as influenced by seediness, thickness of pith, density of the fruit and colour.
g. The chemical quality of the fruit juice as measured by total solids, pH, total acidity, total sugars, vitamin C, ash, and the ratios of acidity/total sugars etc.
h. The N, P, K, Ca, Mg content of the rind, fruit juice, and leaves as an index of the nutritional status of the trees.
i. Soil analyses.

Summary of Results

I. At Grove Place the outstanding responses have been to potash. The following table summarises the *significant* effects of fertilizers on yield (weight of fruit) over the duration of the experiment (crops 1938-45/6).

Level of Fertilizer Applied	*Mean Yield of Fruit by Weight Relative to Control at* 100
Control	100
Single Nitrogen	31
Single Potash	290
Single Potash and Single Nitrogen	360
Double Potash and Single Nitrogen	422
Single Potash and Double Nitrogen	518
Double Potash and Double Nitrogen	526

The figures indicate the importance of obtaining the correct balance in fertilizers but show very conclusively that such balance does not necessarily mean that a fertilizer must contain all three elements N, P, and K. For the optimum treatment the applications have been increased from $1\frac{1}{8}$ lbs. of sulphate of ammonia and $1\frac{1}{3}$ lbs. of sulphate of potash per tree per annum at planting to six lbs. of sulphate of ammonia and four lbs. of sulphate of potash per tree per annum at eight years and older.

The yield data for Wakefield over the cropping years 1941-1944/5 show that responses are obtained from applications of each fertilizer. The following table presents the average significant response obtained for the optimum fertilizer application.

Treatment	*Average Yield (by weight) as a Percentage of Control*
Control	100
Single Level Nitrogen plus .... Single Level Phosphate plus .... Single Level Potash	261

On Wakefield soil the optimum treatment was 1 lb. of sulphate of ammonia, 2 lbs. of 18 per cent. superphosphate and 1 lb. of sulphate of potash per tree per annum applied after planting, and increasing regularly to 3½ lbs. of sulphate of ammonia, 7 lbs. of 18 per cent. superphosphate and 7 lbs. sulphate of potash at six years.

Comparing the results obtained at Grove Place with those at Wakefield it is very evident that soils play a dominant factor in deciding the fertilizer requirements of citrus and that these requirements may show wide variations, both in type of fertilizer required, and in total quantity. The growth rate of the trees at the two sites are also vastly different, as well as the average yield per tree. The experiments show that the quantity of each nutritional element supplied as fertilizer is decided by growth rates and yield and some indication of this quantitative relationship has been obtained.

II. Investigations on the premature drop of potentially marketable fruit show that fertilizers have a very marked effect on the hanging on of fruit to harvest time. Applications of potash and nitrogen produce very significant beneficial effects where these elements are deficient, but superphosphates, though they may produce large increases in crop returns, do not give any significant increase in the number of potentially marketable fruit which fall prematurely.

III. The growth of the trees has shown responses similar to the yield except that the breadth of the canopy is more sensitive to fertilizer treatment than trunk measurements. Stock and scion reacted in the same way to fertilizers. A study of the rate of growth of the trees as influenced by fertilizer treatment stresses the importance of applying the correct fertilizers early in the life of the orchard. *The outstanding influence of fertilizers on tree size in all experiments has been due to heavy growth stimulus produced in the first two years, after planting, after which all trees appear to grow at a constant rate irrespective of fertilizer treatment.*

IV. The average weight per fruit is very sensitive to fertilizer treatment, showing that where potash and phosphates give increased yields, they also result in a much higher average weight per fruit.

V. Core thickness and skin thickness are increased by potash fertilizers but superphosphates added to a phosphate deficient soil reduce skin and core thickness. The overall density of fruit is increased on phosphate deficient soil by an application of superphosphate. Potash fertilizers increase the seediness of fruit.

VI. The quality of fruit juice is very sensitive indeed to fertilizer treatment.

Nitrogenous fertilizers decrease the Vitamin C content. Their effect and other factors varies with soil and possibly climate. Under Grove Place conditions they reduce the ash but have little other effect. At Wakefield on the other hand where nitrogen even when applied alone produces significant increases in yield, nitrogenous fertilizers increase juice ash, electrical conductivity, total solids, citric acid and total sugars. With exception therefore, of Vitamin C, nitrogenous fertilizers applied to markedly nitrogen deficient soils improve juice quality.

Superphosphates on phosphate deficient soils decrease juice ash, electrical conductivity, acidity, sugars and Vitamin C, but increase the ratios of sugars/acidity and decrease acidity/total solids. The significance of these latter ratios is effected by the marked reduction in acidity. Phosphates therefore, when applied to phosphate deficient soils, produce more watery but less acid, fruit.

Potash applied to potash deficient soils increases the ash and electrical conductivity, total solids, refractive index, pH, acidity, total sugars and Vitamin C content of the juice. The overall quality of grapefruit juice is consequently greatly improved. In the case of straight potash deficiencies such as exist at Grove Place the sugars/acidity, sugar/brix and acidity/brix ratios are unaffected but in the presence of nitrogen and phosphate deficiencies, applications of potash increase the acidity of the fruit juice to a greater degree than the sugars or total solids.

VII. The nitrogen, phosphate, potash, calcium and magnesium content of the leaves and the rind and juice of grapefruit reflects fertilizer treatment and the general nutritional status of trees. Work is in progress to try to establish critical minima in the composition of leaves and/or fruit so that this information may be of value in diagnosing nutritional deficiencies in orchards. Results being obtained are very encouraging and certain critical levels of nitrogen phosphorus and potash, and the manner in which variation in one element affects the uptake of the others, have been ascertained. As an example of the type of conclusions drawn, the results obtained on mature leaves only are quoted. Rather similar conclusions have been obtained from a study of the rind and fruit juice.

The nitrogen content of leaves is influenced by the available nitrogen supply in the soil and by the application of potash. Where soil available potash is very deficient the figures fluctuate between 2.0 and 2.8 per cent. dry matter. Taken in association with soil available potash figures, the nitrogen status of mature leaves can give a useful indication of whether the trees are receiving adequate supplies of nitrogen. The critical level of leaf nitrogen per cent. dry matter in all three experiments is about 2.3 per cent. The increased growth from applications of phosphate to phosphate deficient soils has no effect on leaf nitrogen.

The phosphorus content of leaves. As was expected, on phosphate deficient soils, the P_2O_5 content of the leaf increases with applications of this nutrient but on phosphate rich soil, heavy applications of P_2O_5 do not increase leaf P_2O_5. The upper phosphates limits in the leaf are around 0.59 per cent. When figures of under 0.30 per cent have been obtained, marked crop increases result from an application of phosphate, and at this figure the increase in leaf P_2O_5 with increase in P_2O_5 applied to the crop, is almost linear. Heavy applications of nitrogen under conditions

which result in little crop response from this element, suppresses the uptake of phosphates, but not to the point where an application of phosphates increases yield. It would appear therefore that 0.46 per cent P_2O_5 per cent. dry matter in grapefruit leaves is not below the point at which P_2O_5 response in yield, may be expected.

Where phosphates are already a factor limiting yields the P_2O_5 content of the leaves can be further reduced by correcting a potash deficiency which is as would be expected.

The potash content of leaves. Of the major plant food elements potash shows the greatest variation with fertilizer treatment. The minimum adequate level in the leaf is about 1.4 K_2O per cent. dry matter and is confirmed by all three experiments. When nitrogen and phosphate deficiencies also are factors limiting yield, application of these fertilisers in the absence of adequate potash applications, reduce the potash status of the leaf.

As in nitrogen and phosphates luxury consumption of potash can take place, which may give rise to figures as high as 1.9-2.0 K_2O per cent. dry matter.

Calcium content of leaves. Great variation exists between the lime status of trees grown on Terra Rossa at Grove Place (mean CaO per cent. dry matter of leaves=7.6) and trees on acid Inland Basin soils at Wakefield (mean CaO per cent. dry matter of leaves=4.9). From the experiments it is not possible to tell where the level of adequacy lies. The difference is primarily due to the different lime status of the two soils. Any physiological effects arising from potash deficiencies are probably balanced by the rather corresponding degree of lack of this element in both soils. (The effect of applying potash to the two soils has produced changes of the same magnitude and values in the potash of the leaves.) On both soils correcting of the potash deficiency reduces the lime uptake which may be a straight physiological effect or if the lime is actually deficient in both soils, is probably the result of an increased growth rate. From similar work on oranges in Palestine and South Africa it would appear that the Grove Place soil is adequate in lime status but that the Wakefield soil of on the border of actual lime deficiency.

Magnesium oxide content of leaves. By South African standards (on oranges) all experiments are adequately supplied with magnesium, the mean figures for the two experiments on Terra Rossa being 0.75 and 0.76 MgO per cent. dry matter, and 1.11 per cent. for Wakefield trees. Fertilizer treatment has had no effect upon the uptake of magnesium on either soil type, probably due to the high magnesium status of the soils.

Ash per cent dry matter of leaves. The total uptake of minerals is very sensitive to applications of nitrogenous fertilizers, which reduce the ash content of the leaves very significantly.

The N/K_2O ratio of leaves. All three experiments show wide N/K_2O ratios in the control plots. (Greater than 4.0) and on both soil types the optimum ratio appears to be around 1.7. Ratios well above 1.7 would suggest that the responses to be expected from application of potash will be considerably greater than those expected from applications of nitrogen, which is in fact, confirmed by all three experiments.

The N/P_2O_5 ratios of leaves. The ratio varies, between 9.0 and 4.0 and from the data available the significance of this ratio is not obvious.

The K_2O/P_2O_5 ratio of leaves. The ratio is much more sensitive to applications of potash than to applications of phosphates, even when the phosphate deficiency is much more acute than the potash deficiency. A figure of around 2.5 to 3.5 would indicate nutritional balance but this can be attained by a balanced deficiency of P and K as well as by optimum amounts. The factor is of value only when considered along with the N, P, and K composition of the leaf.

VII. *Soil Analyses*

Soil analytical data has been collected for each experiment site. It is concluded that a minimum soil potash status considerably in excess of 150 parts per million of available potash (Williams' method) is required by grapefruit and that the available phosphate status of a soil (Truog method) must be much in excess of 15 parts per million P_2O_5, but not as high as 40 parts per million. Insufficient data is available to arrive at any indication of the critical Nitrogen status of soils.

Programme of Future Work

It is proposed to put the following work on hand at an early date :—

(*a*) An examination of the main citrus soil of the Colony to ascertain by chemical means their nutritional status.

(*b*) Simultaneous with (*a*) an examination of the chemical composition of mature leaves of trees from all orchards where the soils are examined.

(*c*) The data obtained from (*a*) and (*b*) should be classified as a result of which, a limited number of orchards should be selected on which to place simple observation plots to test the effectiveness of fertilizer advice based upon the data obtained from soil and plant analysis, and the basic fertilizer experiments already carried out. One example of this is already in operation at Seven Rivers in St. James.

(*d*) Experiments and observation plots to identify minor element deficiencies and to estimate their economic importance.

Acknowledgment

The field work was carried out with the help and supervision of the Agricultural Officers in charge of Grove Place Experiment Station and their Subordinate Staff; the Foreman in charge of the Citrus Experiment at Wakefield; and the Subordinate Staff of the Agricultural Chemist's Laboratory, Hope. The whole of the analytical work, both statistical and chemical was undertaken by the Staff of the Agricultural Chemistry Division.

CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Magnesium Chlorosis

T. Walsh and E. J. Clarke have made the interesting suggestion that a chlorosis of tomatoes due to magnesium deficiency should be controlled by attention to the level of potassium, rather than by the addition of magnesium compounds (*J. Roy. Hort. Soc.*, 70, Pt. 7; 1945). They show that the chlorosis is associated with high values of potash, that its appearance depends largely on the ratio of potassium to magnesium, and that high concentrations of mineral nutrients in the soil lower the yield of tomatoes. There is an increasing volume of evidence, apart from that presented in this short paper, that the tomato crop is often over-manured. Additions of magnesium compounds would only add to this difficulty, and there appears to be sufficient magnesium for good growth in the Irish soils investigated, when the potash is kept at a suitable level.—(*Nature*, 1946, Vol. **157**, p.702.)

* * *

Magnesium Chlorosis of Tomatoes

The summary in *Nature* (1) of the paper by Walsh and Clarke (2), directs attention to the methods of treating tomato plants affected by induced magnesium deficiency. The paper emphasizes the importance in this connexion of the potash level in the soil, a relationship which was previously described by Cromwell and Hunter (3), and a review of the position may be timely.

Jones, Nicholas and Wallace (4), and Jones, Nicholas, Wallace and Jefferiss (5), stated that good control of magnesium deficiency in tomatoes was obtained by heavy applications of magnesium sulphate to the soil. Similar treatments given during several years in south-western Scotland have been effective.

In sand-culture experiments conducted in the West of Scotland Agricultural College, absorption of magnesium decreased with increasing concentration of the solution in which the plants were growing; this effect of concentration was as important as was the ratio of ions in the solution: when the solution was relatively concentrated and also the ratio of potassium to magnesium in it was high, then the absorption of magnesium was most restricted and the chlorosis was most severe. The conductivity of soil surrounding chlorotic plants was always found to be high, and usually to be higher than that of neighbouring soil bearing healthy or less severely affected plants. A critically high concentration of soluble salts in the soil would thus probably be harmfully increased by applications of magnesium salts.

It has already been pointed out by Cromwell and Hunter (3) that this type of chlorosis may also be caused by factors other than the potash status of the soil.

In sand-culture and glasshouse work in this College, induced chlorosis in tomatoes was associated particularly with the use of potassium sulphate as a fertilizer, though excessively applications of other potassic fertilizers also induced the deficiency. The effect of potassium sulphate probably arises from the different rates of absorption of its ions. The chlorosis was not increased by raising the sulphate content of the tomato soils or sand-cultures above the normal level by means of sodium sulphate or calcium sulphate, the amounts of other fertilizers applied being adjusted to keep the concentration of soluble salts approximately constant.

That control of the chlorosis may be obtained by repeatedly spraying the foliage with magnesium sulphate solution has been reported by Jones, Nicholas, Wallace and Jefferiss (5), and control was obtained in this area when the plants were sprayed sufficiently often. It seems unlikely that spraying treatment will have practical value in the West of Scotland College area.

Several different types of soil cultivation for glasshouse tomatoes have been investigated at the College, but none was found effective in controlling the chlorosis.

Results obtained this season by, for example, early mulching with farmyard manure or peat suggest, however, that an encouragement of secondary root production may go far to offset the condition under which induced magnesium deficiency appears.

This work has been done by co-operation between the Departments of Chemistry and Horticulture at the College.

Until new cultural methods have been fully investigated, the cure for induced magnesium deficiency, if it persists when the potash dressings are kept as low as possible, seems to lie in resoiling and, taking into account the other advantages of resoiling, this may be economic.—(Letter from J. G. Hunter published in *Nature*, Vol. **158**, p. 25, 1946).

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